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RATES AND PATTERNS OF EROSION ON INTER-TIDAL SHORE PLATFORMS, KAIKOURA PENINSULA, SOUTH ISLAND, NEW ZEALAND

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ABSTRACT

This paper presents measured rates of erosion on shore platforms at Kaikoura Peninsula, South Island, New Zealand. Surface lowering rates were measured with a micro-erosion meter and traversing micro-erosion meter. The mean lowering rate for all shore platforms was 1·130 mm a^{-1}. Differences in lowering rates were found between different platform types and lithologies. The rate of surface lowering on Type A (sloping) mudstone platforms was 1·983 mm a^{-1}, and 0·733 mm a^{-1} on Type B mudstone platforms (subhorizontal). On limestone platforms the lowering rate was 0·875 mm a^{-1}. A previously reported cross-shore pattern of surface lowering rates from Kaikoura was not found. Rates were generally higher on the landward margins and decreased in a seaward direction. Season is shown statistically to influence erosion rates, with higher rates during summer than winter. The interpretation given to this is that the erosive process is subaerial weathering in the form of wetting and drying and salt weathering. This is contrary to views of shore platform development that have favoured marine processes over subaerial weathering. © 1998 John Wiley & Sons, Ltd.

KEY WORDS: shore platform; micro-erosion meter; traversing micro-erosion meter; Kaikoura Peninsula; subaerial weathering

INTRODUCTION

Shore platforms are commonly defined as horizontal or near-horizontal rock surfaces at the shore line. Although a large body of literature exists, a satisfactory explanation of how shore platforms develop has not been forthcoming, because the roles of different processes leading to development have not been fully identified. It was argued by Dana (1849), Bartrum (1924, 1926), Edwards (1941, 1951), Sunamura (1978, 1992) and Trenhaile (1987) that the primary agent of shore platform development is the erosive force of waves; while Bartrum (1916, 1938), Wentworth (1938, 1939) and Hills (1940) identified subaerial weathering as the formative process. This difference of views led to a ‘wave versus weathering’ debate. However, the action of both processes in concert has also been stated by Bell and Clarke (1909), Bartrum and Turner (1928), Bartrum (1935), Jutson (1939), Mii (1962) and Kirk (1977). In the last ten years the role of waves in platform development has dominated the views of the small number of researchers working on platform studies (e.g. Trenhaile, 1987; Tsujimoto, 1987; Sunamura, 1990, 1991, 1992, 1994). This is surprising because the precise role of marine and subaerial processes in platform development is still not fully understood. At no time has it been clearly demonstrated that either process is principally the cause of platform development.

One reason for this situation is that the bulk of early research was characterized by qualitative, explanatory and descriptive writing, even to the point that morphology was described in words. There was almost no attempt to quantify either the processes or the rates of morphological change. In 1970, however, a technique was introduced that enabled very accurate measurements of surface change. The micro-erosion meter (MEM) was introduced by High and Hanna (1970) as a technique for measuring small rates of erosion of bedrock. This allowed surface elevation at three positions to be measured at an MEM site. Investigators saw the potential to explore questions concerning the age and rate of development of shore platforms and to investigate the

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Table I. Summary of published erosion rates on coastal shore platforms measured using the MEM and TMEM

Authors	Mean annual erosion rate ($mm\,a^{-1}$)	Lithology and morphology	Location
Stephenson and Kirk (1996)	1·48	Inter-tidal limestone and mudstone	Kaikoura Peninsula, New Zealand
Mottershead (1989)	0·625	Supratidal green schist	Start-Prawle Peninsula, Devon, UK
Viles and Trudgill (1984)	1·97	Limestone, raised coral reefs	Aldabra Atoll, Indian Ocean
Gill and Lang (1983)	0·37	Greywacke intertidal platforms	Otway Coast, Victoria, Australia
Spencer (1981)	0·38	Limestone, raised coral reef	Grand Cayman Islands, West Indies
Spencer (1985)	0·09 to 1·77	Limestone, raised coral reefs	Grand Cayman Islands, West Indies
Kirk (1977)	1·53	Intertidal limestone and mudstone	Kaikoura Peninsula, New Zealand
Robinson (1977a,b)	0·0 to 0·9	Intertidal shale ramp and platforms	Yorkshire, UK
Trudgill (1976a,b)	1·01 to 1·25	Limestone, raised coral reefs	Aldabra Atoll, Indian Ocean

processes causing erosion such as, how old are shore platforms, and how fast do they develop? Both questions have become important as it has been demonstrated that some shore platforms are relict features from previous interglacials which have been reactivated during Holocene sea level rise (Phillips 1970a,b). Thus some platforms have undergone more than one episode of development. If rates of development could be measured then possible ages of shore platforms could be determined to answer some questions concerning inheritance.

A number of published rates of vertical surface lowering on shore platforms are now available (Table I). Some of these have also enabled interpretation of processes operating on shore platforms. However, some caution is needed when interpreting process from morphological change because morphology can be an ambiguous indicator of process. Further caution is required because MEM data cannot always separate out individual processes when several may be involved.

Using an MEM, Kirk (1977) measured surface lowering on mudstone and limestone platforms on Kaikoura Peninsula, South Island, New Zealand. Measurements revealed that erosion varied across the platform profile. On the inner landward side and the outer seaward side erosion rates were higher than on the middle of the platform profile. The interpretation given to this was that the inner part of a platform was dominated by subaerial and supralittoral processes while the outer part was dominated by marine processes, and that there was a grading of the two towards the middle of the platform. Thus there was a gradient across the platform from subaerial processes at the landward edge to true marine processes at the seaward edge.

While the number of erosion rates published has increased, there are still few published results from use of the traversing micro-erosion meter (TMEM) (Spencer (1981, 1985) are exceptions). This modified version of the MEM allows a greater number of measurements to be collected, and this is useful as the MEM has a limited spatial coverage. The TMEM has the potential to provide greater insight into erosive processes with the improved volume of data it yields. This greater volume of data may also improve knowledge of erosion rates on shore platforms. So far the TMEM has been under-utilized in shore platform studies. This investigation seeks to address this to improve knowledge of surface lowering rates on shore platforms and elucidate processes from these data.

TERMINOLOGY

Figure 1 shows two major morphologies of shore platforms that have been identified: platforms that slope gently into the sea, and those that are nearly horizontal and terminate abruptly with a cliff or ramp at the seaward edge (Sunamura, 1992). Sunamura distinguished between the two platform morphologies by assigning the designations Type A to sloping platforms and Type B to horizontal platforms (Figure 1). Tsujimoto (1987) provided a quantitative relationship that distinguished between Type A and Type B profiles, based on wave force and the compressive strength of the rock forming the platform. It was proposed that when wave force exceeds 8 per cent of the compressive strength, platform development begins by the cutting of a notch in a cliff

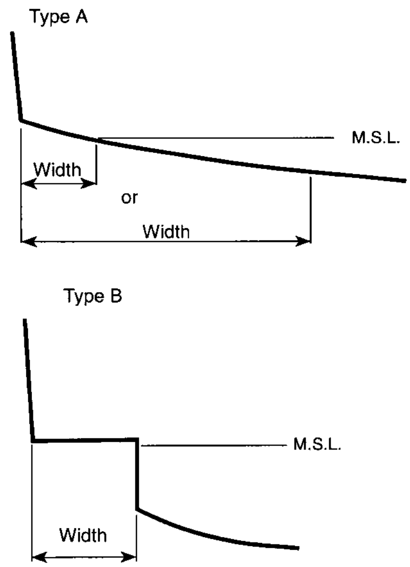

Figure 1. Two types of shore platform, Type A and Type B (Sunamura, 1992, Figure 7.2)

at still water level. Tsujimoto proposed that the critical condition for demarcating Type A and Type B platforms is determined by whether or not the initial seaward cliff is preserved or destroyed. If it is destroyed, then he suggested a Type A platform results, but if it remains, then a Type B platform should be formed. The destruction of the seaward cliff results from surface lowering of the floor of the notch. The critical formative condition between Type A and Type B was suggested to be dependent on the occurrence of surface lowering. According to Tsujimoto (1987) no surface lowering occurs on Type B platforms because the strength of the rock is too high for waves to cause erosion.

STUDY AREA

Kaikoura Peninsula is located on the east coast of the South Island of New Zealand at 42° 25′ S and 173° 42′ E (Figure 2). It has been described in detail by Kirk (1977) and recently by Stephenson and Kirk (1996). Geologically the peninsula consists of an asymmetrical anticline bounded on either side by two synclines, the axis of which strikes northeast–southwest (Chandra, 1968; Duckmanton, 1974). Two sedimentary rock types make up the peninsula, Palaeocene Amuri Limestone and Oligocene Grey Marls (mudstone). Intense folding and minor faulting occur, particularly in the limestone area. Shore platforms are developed in both lithological units, those in limestone displaying wider variability in morphology. Based on measured rates of cliff retreat and surface lowering, Kirk (1977) concluded that platforms at Kaikoura are contemporary features developed at the present sea level.

The shoreline of Kaikoura Peninsula is exposed to unlimited fetch, and the wave climate can be characterized as a high energy oceanic swell environment, where long periods of relatively calm seas are interrupted by high energy storms. High energy storms relate to the passage of cyclonic depressions over New Zealand, and these can occur at any time of the year (Kirk, 1977). There is no seasonal pattern to the passage of storms or high energy sea states. The climate of the Kaikoura area is temperate with average annual rainfall of 888 mm a^{-1}, and mean monthly temperatures range from 7·7°C in July to 16·2°C in January. The Kaikoura environment is highly energetic with regard to both marine and weathering processes. Shore platforms are exposed to the dominant wave directions and are in the inter-tidal zone. This means that both marine erosive forces and subaerial weathering processes can contribute to erosion.

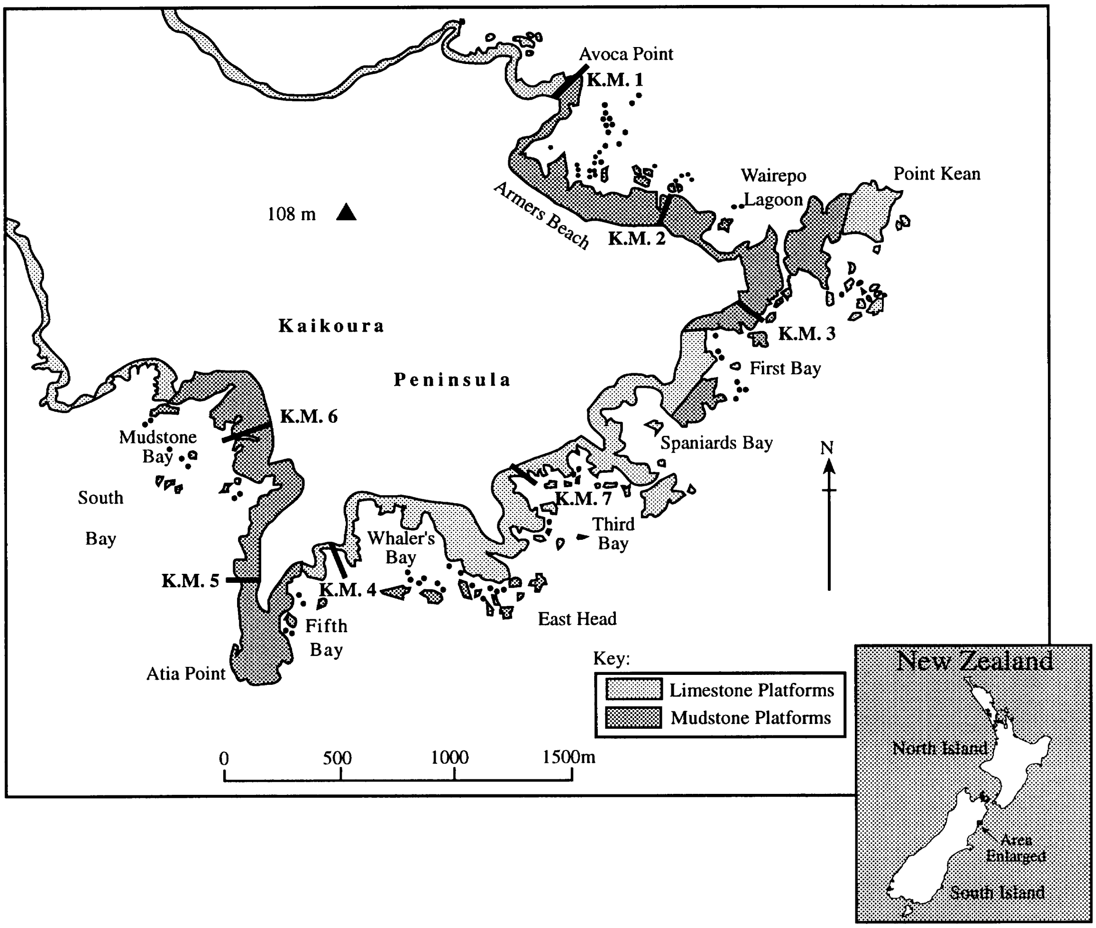

Figure 2. Shore line of Kaikoura Peninsula showing locations of shore platforms and study sites discussed in the text

METHODS

The MEM was first described by High and Hanna (1970) and used to measure relatively slow rates of erosion on rock surfaces. Trudgill *et al*. (1981) presented the TMEM, a modified version of the MEM. The TMEM differs in that the dial gauge is independent of the base and is mounted on a block with three arms separated at 120° intervals. The centre of the MEM base plate is cut out to allow the dial gauge to be moved within that area. The dial gauge can be moved to a number of different positions by locating each horizontal arm between ball bearings fixed along the sides of the base. The TMEM utilizes the same bolt sites as the MEM because it has the same leg spacing and configuration. Stephenson (1997a) further modified the TMEM by fitting it with a digital dial gauge and connecting this to a laptop computer via an optical RS 323 cable. Previous examples had used an analogue gauge which required the operator to read and physically record results. This was considered to be too restrictive given the time constraints of working on shore platforms in the intertidal zone where a large data set was being generated. The TMEM used at Kaikoura allows 120 individual measurements to be made at a bolt site.

In 1973, Kirk (1977) established 31 MEM bolt sites around the Kaikoura Peninsula on six profiles. Fifteen of these bolt sites remain operational today. Stephenson and Kirk (1996) presented results from remeasurements of these bolt sites and calculated surface lowering rates from 20 years. It was found that the mean rate of lowering was 1·43 mm a^{-1} compared with 1·53 mm a^{-1} reported by Kirk (1977). As part of a wider study into

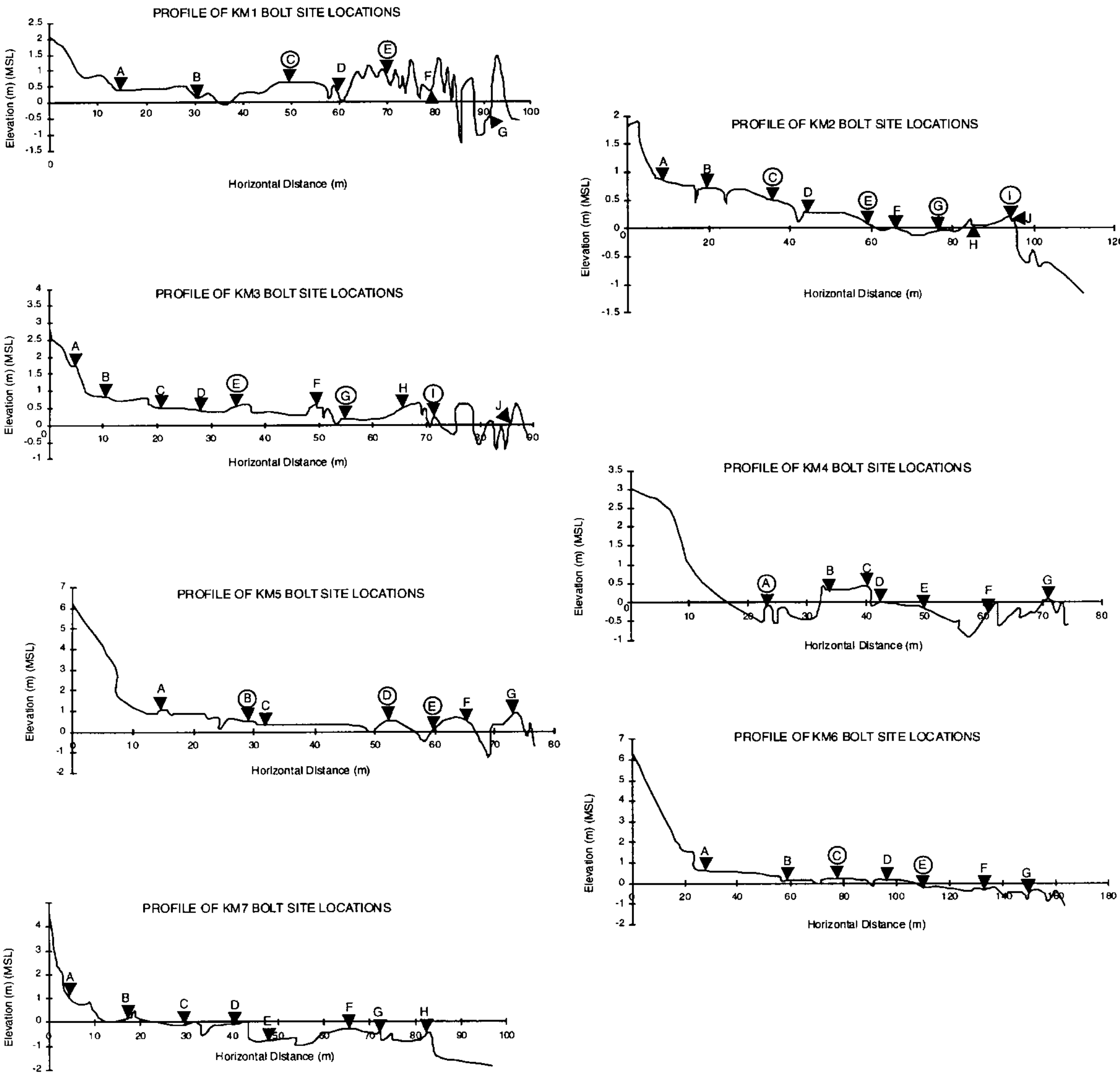

Figure 3. Shore platform profiles showing locations of MEM bolt sites. Circled letters indicate bolt sites installed in 1973 by Kirk (1977)

shore platform development Stephenson (1997b) continued measurements on these sites and installed 42 new bolt sites on the same profiles established by Kirk (1977). A new profile was established to increase representation of limestone platforms. The locations of each profile on the peninsula are given in Figure 2 and locations of each of the bolt sites on the seven profiles are shown in Figure 3. General characteristics of each profile are contained in Table II. Two profiles are located on Type A mudstone shore platforms (KM2 and KM6) and three on Type B mudstone platforms (KM1, KM3 and KM5). Two profiles are located on Type A limestone platforms (KM4 and KM7).

RESULTS AND DISCUSSION

Between December 1993 and March 1996 each bolt site was visited either six or seven times. The maximum length of the measurement record was exactly 800 days. Not all visits to bolt sites resulted in measurements (for

Table II. Characteristics of shore platform profiles used for this sudy

Location	Profile	Mean elevation (m rel. to m.s.l.)	Length (m)	Slope	Orientation (mag.)	Strike (mag.)	Dip	Platform type	Lithology	Backshore
Avoca Point	KM1	0·384	91	0°53′37·47″	031°	130°	–33°	B	Mudstone	Pebble and cobble beach and road
Wairepo Lagoon	KM2	0·214	88	0°30′15·15″	330°	240°	+40°	A	Mudstone	Pebble beach and road
Point Kean	KM3	0·406	85	1°16′10·08″	102°	013°	–9°	B	Mudstone	Eroding cliff
Whaler's Bay	KM4	–0·226	52	0°13′34·74″	140°	290°	+10°	A	Limestone	Pebble and cobble beach
Atia Point	KM5	0·340	65	0°10′ 8·48″	240°	160°	+30°	B	Mudstone	Eroding hill
Mudstone Bay	KM6	–0·074	137	0°26′28·21″	206°	300°	–30°	A	Mudstone	Eroding lagoon deposit
Third Bay	KM7	–0·241	78	0°55′20·58″	108°	024°	+30°	A	Limestone	Eroding cliff

Table III. Efficiency of TMEM and MEM data collection

	TMEM	MEM
Total possible measurements	35 280	315
Actually attained	24 055	305
Efficiency (%)	67	97

reasons explained below), so that the number of times measurements were taken varied from two to seven. The efficiency of data collection is summarized in Table III.

A number of problems were experienced during the data collection period that prevented a 'complete' set of data from being gathered. The most common reason was the growth of algae on platform surfaces particularly from April to September (winter) each year, although in some locations this would persist into November and December. Another problem was that on occasions rough seas and high water levels prevented the more seaward bolt sites from being reached. A further problem encountered was that not all 120 readings could always be obtained from the TMEM. In some instances the topography of the bolt site was such that the spindle of the gauge could not reach the surface, or the surface was too high, not allowing the spindle to travel at all.

An early result from measurements was that not all measurements indicated surface lowering at subsequent readings. It appeared as if the surface had elevated. This phenomenon was attributed to swelling of the rock surface, as had been previously reported by Kirk (1977) and by Mottershead (1989). Readings that indicated swelling were separated from those that showed lowering, in order to calculate lowering rates. No swelling data are presented here, but a detailed examination of the phenomenon is the subject of a paper in preparation.

Erosion data

An early observation was that erosion rates (expressed as an equivalent mean annual rate) between measurements were higher during summer than winter. Therefore summer and winter periods were separated and averaged to provide an equivalent mean annual rate for each bolt site for summer and winter (Figures 4 to 10). Also contained in Figures 4 to 10 are grand means (mm a^{-1}) for each bolt site derived from the total erosion measured between the first and last measurement periods at each bolt site. It is not the average of the winter and summer values. Insufficient data were gained from KM6 to calculate seasonal erosion rates because of algal growth.

Grand mean lowering rates show a wide degree of scatter from 0·154 (KM5C) to 9·194 mm a^{-1} (KM6A). Examples of high summer, low winter erosion can be found on all seven profiles though there were some exceptions to this pattern, most notably on KM4 and three bolt sites on KM3. Also significant is the marked difference between erosion rates in summer and winter months at the same bolt site, often by an order of magnitude. The finding that erosion rates and swelling were higher during summer and spring months is evidence of there being a seasonal control on erosion rates. Other MEM studies have also suggested a seasonal control. Robinson (1977a,b) found that erosion at the cliff foot was higher in winter than in summer. It was suggested that this was because storms were more frequent in winter, while weathering processes such as

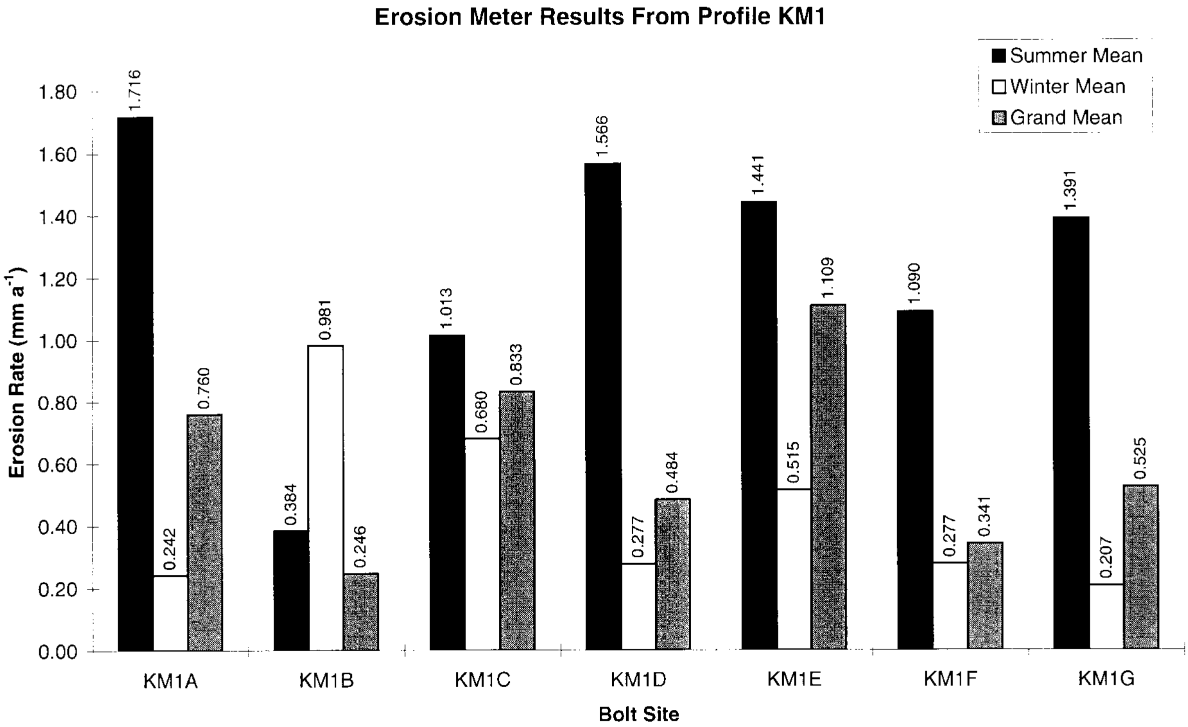

Figure 4. Mean erosion data for summer and winter from each bolt site on KM1 as an equivalent mean annual rate of erosion. Also shown is the grand mean for each site calculated from the total surface lowering

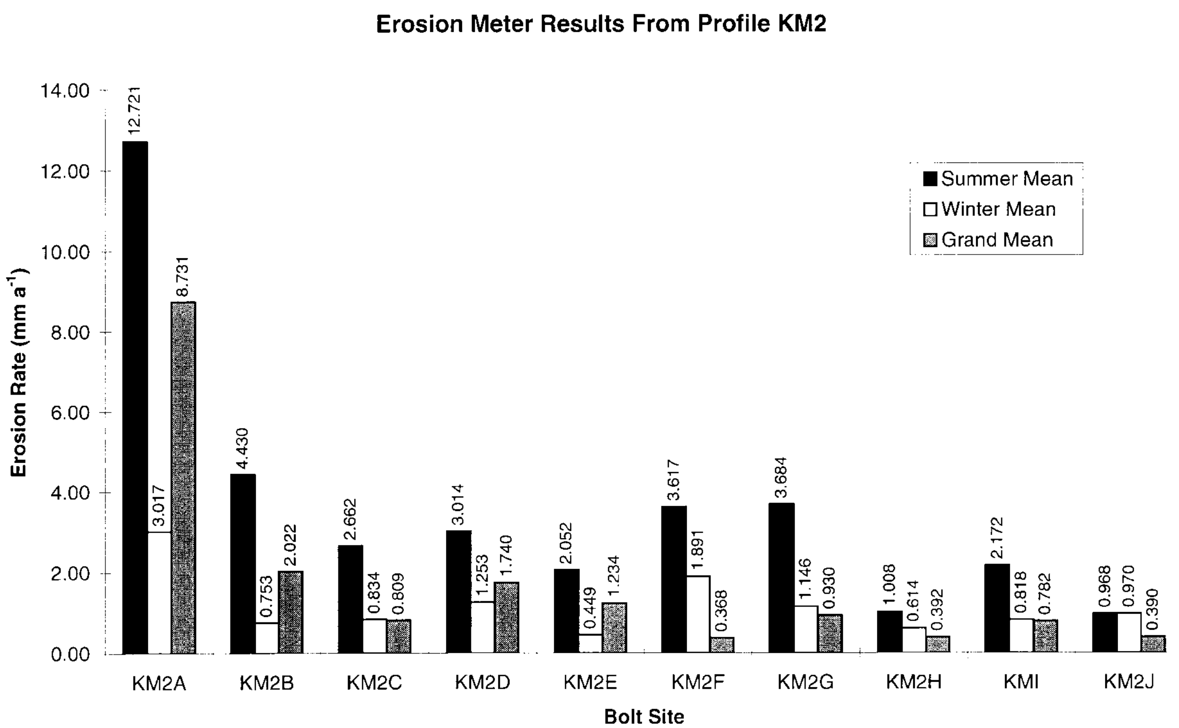

Figure 5. Mean erosion data for summer and winter from each bolt site on KM2 as an equivalent mean annual rate of erosion. Also shown is the grand mean for each site calculated from the total surface lowering

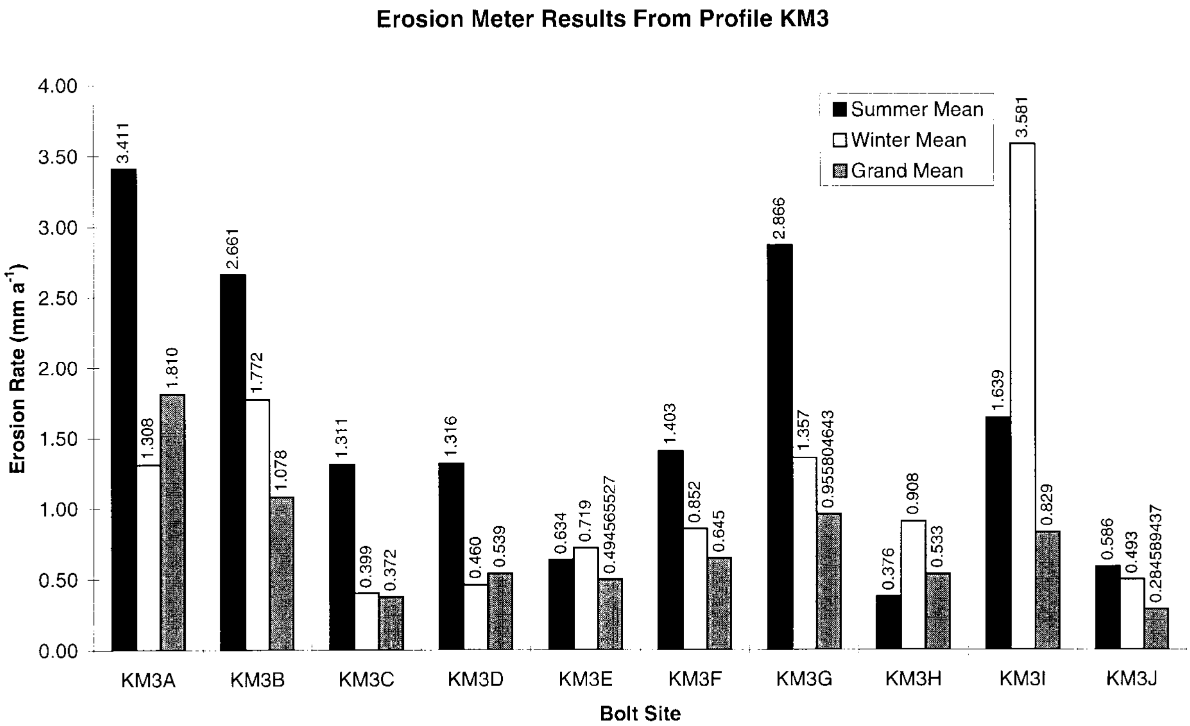

Figure 6. Mean erosion data for summer and winter from each bolt site on KM3 as an equivalent mean annual rate of erosion. Also shown is the grand mean for each site calculated from the total surface lowering

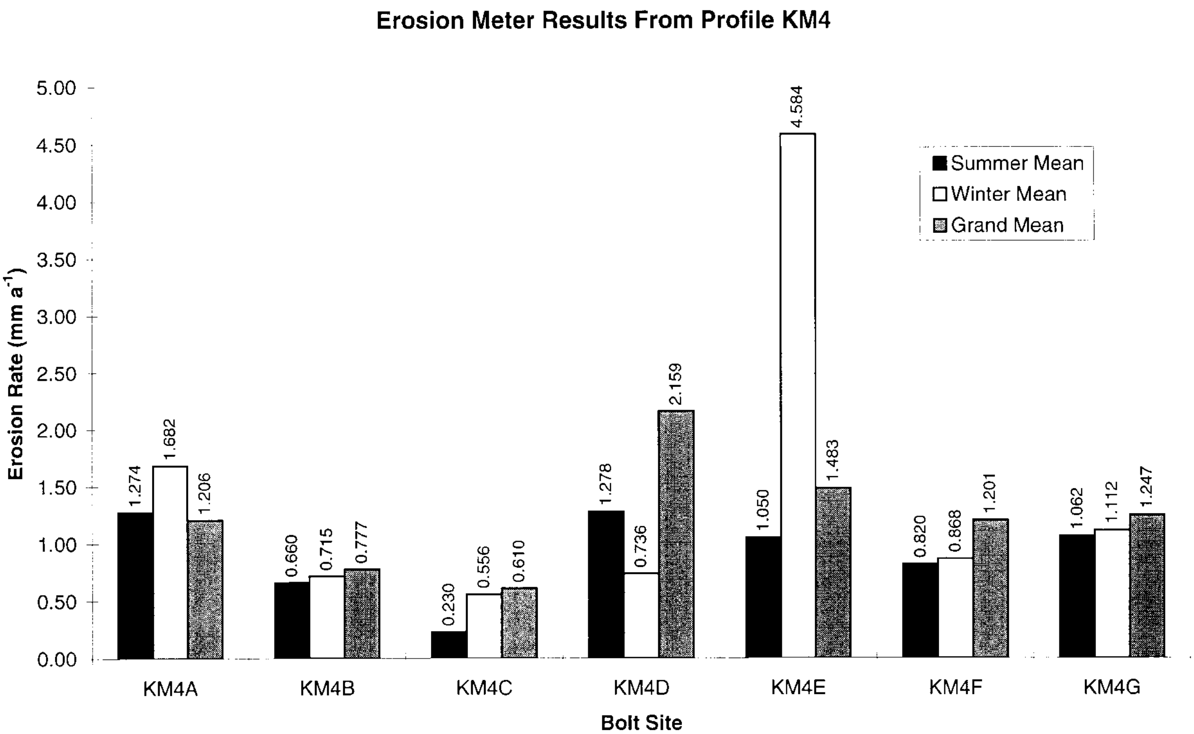

Figure 7. Mean erosion data for summer and winter from each bolt site on KM4 as an equivalent mean annual rate of erosion. Also shown is the grand mean for each site calculated from the total surface lowering

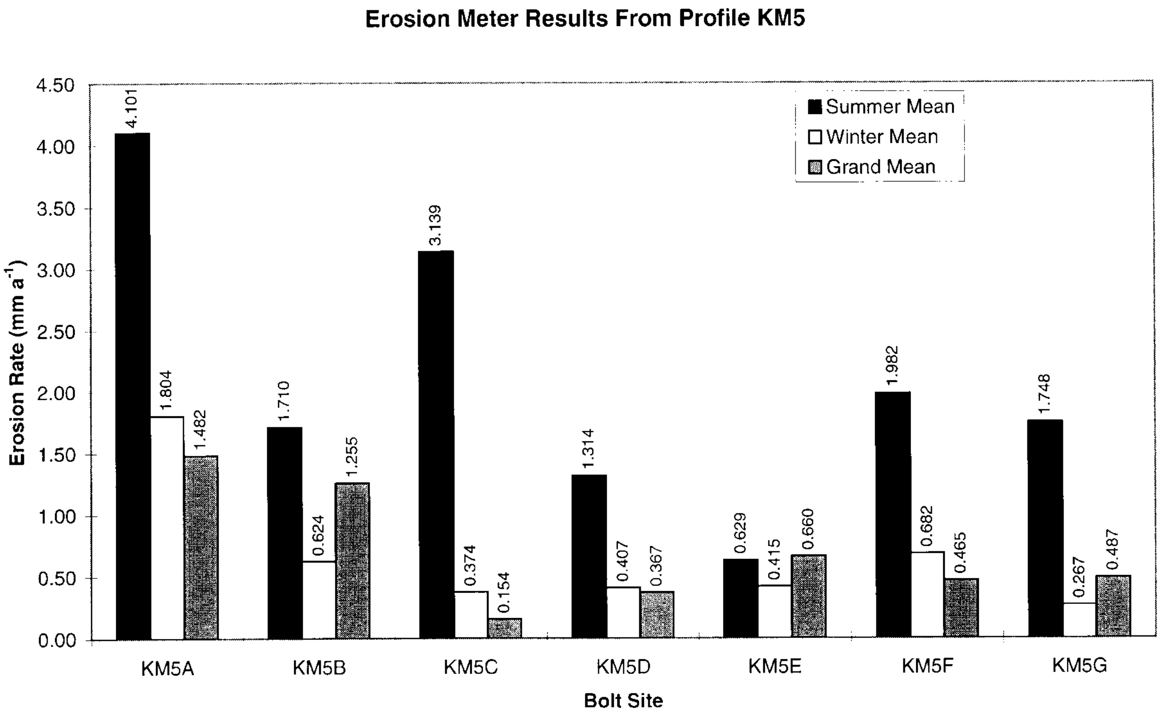

Figure 8. Mean erosion data for summer and winter from each bolt site on KM5 as an equivalent mean annual rate of erosion. Also shown is the grand mean for each site calculated from the total surface lowering

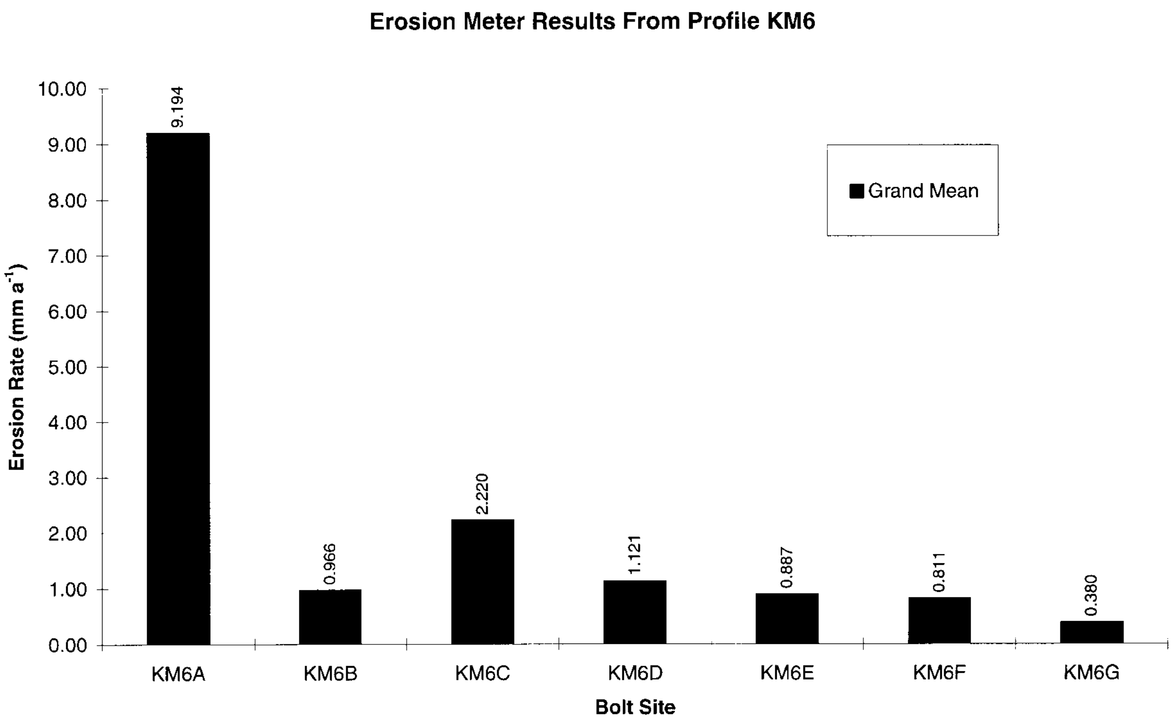

Figure 9. Grand mean erosion data for each bolt site on KM6 calculated from the total surface lowering (insufficient data were gained to calculate seasonal erosion rates)

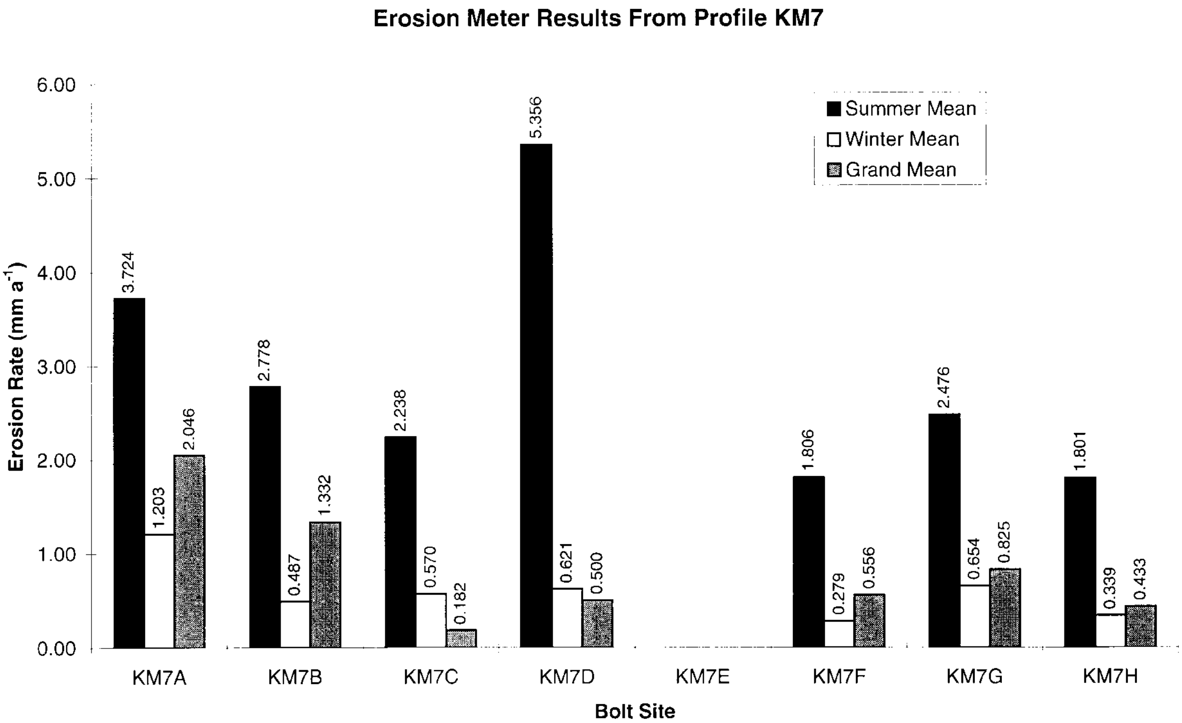

Figure 10. Mean erosion data for summer and winter from each bolt site on KM7 as an equivalent mean annual rate of erosion. Also shown is the grand mean for each site calculated from the total surface lowering

wetting and drying are more common in summer months. Mottershead (1989) found that erosion rates on a supratidal platform were highest during summer months and were positively correlated with monthly average air temperature.

Seasonality in erosion data

Surface lowering data presented above indicate that there is a seasonal pattern to erosion. A link between erosion and season would provide evidence that subaerial weathering is an erosional agent on shore platforms at Kaikoura, for two reasons: (1) there is a seasonal variation in the subaerial weathering environment because summer provides higher temperatures for drying; and (2) storm wave activity on the Kaikoura coast does not have a seasonal pattern so that if marine processes were dominant a seasonal pattern in erosion rates would not occur.

Both wetting and drying, and salt weathering have been proposed as weathering processes on shore platforms (Bartrum, 1935; Wentworth, 1938, 1939). To test whether or not a relationship exists, chi-square χ^2 tests were carried out on 34 individual TMEM bolt sites and these were combined for each profile. Eight were excluded because they did not yield enough data. The form of χ^2 test used was a 2×2 contingency table of swelling and erosion against winter and summer (Shaw and Wheeler, 1985). The test was carried out for individual bolt sites and then on combined data for each profile.

The results of the χ^2 test are summarized in Table IV. The first result was that for all profiles the χ^2 statistic exceeded the critical value and H_o was rejected when $\alpha = 0{\cdot}001$; that is, erosion for all profiles is linked with season. For 25 of the individual bolt sites H_o was rejected when $\alpha = 0{\cdot}001$ because the χ^2 statistic exceeded the critical value. However, this was not the case for nine of the bolt sites. These χ^2 tests showed that for 74 per cent of all bolt sites surface change (both swelling and lowering) was linked with season, with higher values in summer.

Table IV. Chi-square 2×2 contingency table results of swelling and surface lowering against season

	Profile	Individual bolt sites
Reject H_o $\alpha = 0{\cdot}001$	7	25
Accept H_o $\alpha = 0{\cdot}001$	0	9

Cross-shore variations in erosion rates

Kirk (1977) found erosion rates were higher on the inner and outer margins of shore platforms at Kaikoura and from this proposed that weathering and marine processes operated zonally across the platform profile. To test this, the erosion rates were standardized using the equation:

$$B_z = \frac{(B_T - B_{\bar{x}})}{B_{\bar{x}}} \tag{1}$$

where B_z = standardized erosion rate (dimensionless), B_T = the equivalent annual erosion rate of an individual bolt site, $b_{\bar{x}}$ = mean erosion rate for all bolt sites on a given profile (note that $B_{\bar{x}}$ varies from profile to profile).

Standarized data allow direct comparison between bolt sites across a given profile. Each profile is treated individually and B_z is calculated for each bolt site on a profile. Negative values denote erosion rates less than the mean for the profile while positive values indicate erosion rates greater than the mean. If Kirk's (1977) hypothesis is correct then high erosion rates on the seaward and landward margins would be expected. In Figure 11 the expectation would be to see positive values on the inner bolt sites such as A and B and the outer sites G, H and J depending on which profile is being considered. Clearly from Figure 11 this pattern does not exist. On profiles KM1, KM2, KM3, KM5, KM6 and KM7 there is a general patttern of decreasing erosion rates in a seaward direction. Profile KM4 shows a mixed cross-shore pattern with no discernible gradient. These data do not support the hypothesis proposed by Kirk (1977). The general pattern that is evident in Figure 11 is that erosion rates are higher on the inner landward bolt sites and decrease in a seaward direction.

Mean erosion rates

Table V presents a summary of the micro-erosion data collected from Kaikoura. It is arranged so as to show an equivalent mean annual erosion rate (mm a^{-1}) for each profile. Values have been derived by averaging the mean annual erosion rate from each bolt site on the profile. Data in Table V are also separated to show differences between platform type and lithology. Kirk (1977) reported a grand mean for surface lowering from the Kaikoura Peninsula of 1·53 mm a^{-1} and 1·43 mm a^{-1} was reported by Stephenson and Kirk (1996). From this study, mean lowering was 1·130 mm a^{-1}. Compared with other MEM studies, mean rates from this study are in the middle of the range of values in Table I. One possible reason for the slightly lower mean rate than that reported by Kirk (1977) and Stephenson and Kirk (1996) is the higher number of bolt sites on limestone platforms used for this study compared with the two previous reports. Another reason is that TMEM data are drawn from a separate population from the MEM data. To test this, a Student's *t*-test for independent samples was conducted using grand mean lowering rates from each bolt site. This yielded a *t*-statistic of 0·31, and a *t*-critical value of 1·5, at 1 per cent probability. Clearly there is no difference in means, and data from both the TMEM and MEM are derived from the same population. This result provides reassurance that it is valid to combine MEM and TMEM data in studies like this one.

Effect of rock type on erosion rates

There appears to be a clear difference in erosion rates between lithologies, with mudstone platforms eroding at a rate of 1·233 mm a^{-1}, compared with limestone platforms eroding at 0·875 mm a^{-1}. A Student's *t*-test was used to establish whether the observed difference was significant. The *t*-statistic = 0·405 with 54 degrees of freedom and *t*-critical = 1·673; therefore H_o cannot be rejected and differences in erosion rates may not be as a result of differences in lithology. Data in Table V show that there are differences between Type A and Type B shore platform erosion rates. Type A shore platforms in mudstone eroded at a rate of 1·983 mm a^{-1}, compared

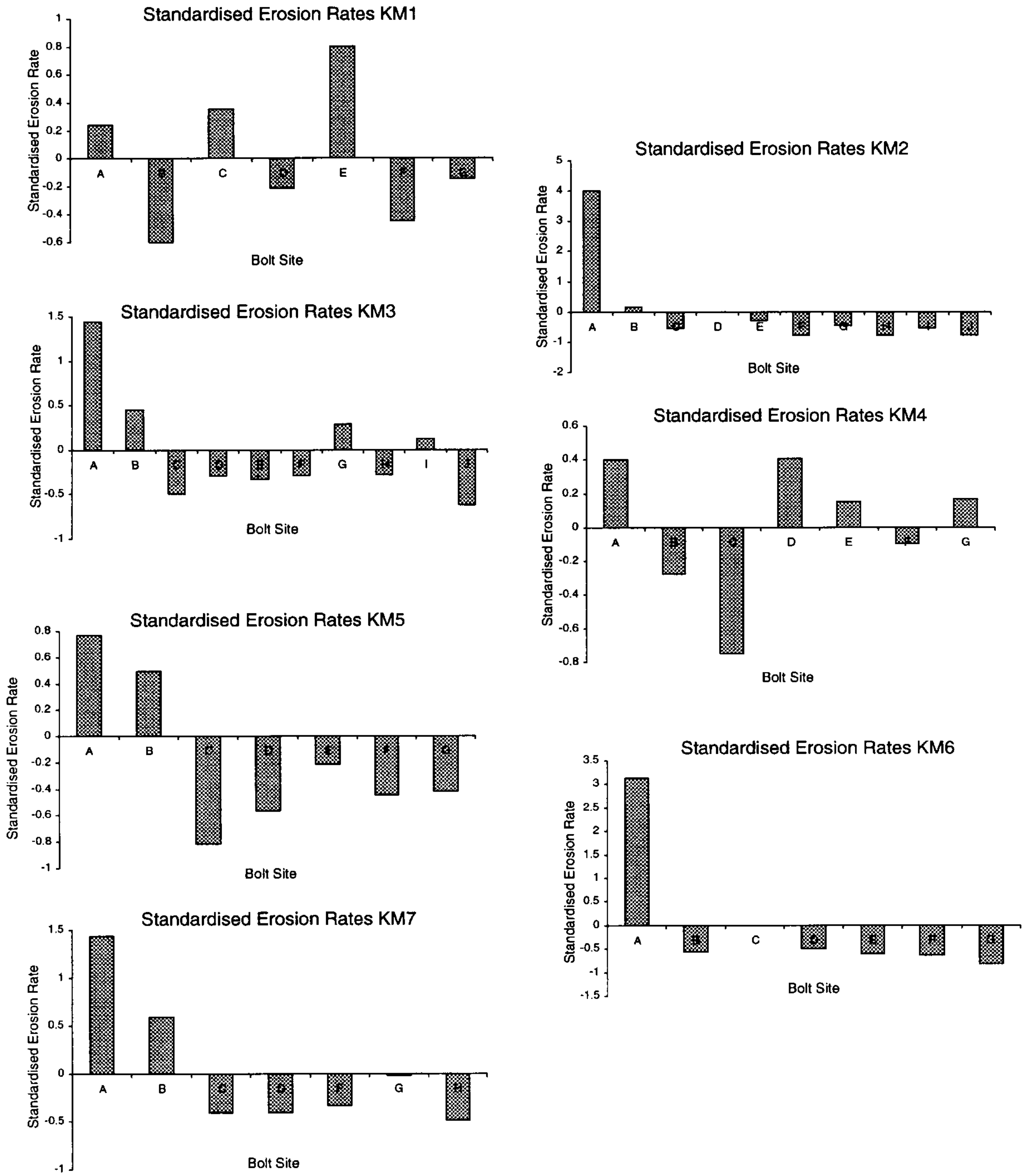

Figure 11. Normalized erosion rates showing cross-shore variations. Trends are indicated by regression lines

with 0·733 mm a^{-1} on Type B platforms. Even when limestone and mudstone Type A platforms are grouped together, the erosion rate of 1·428 mm a^{-1} is still higher than for Type B platforms. Again, a Student's t-test was used to discover whether this difference was significant. The t-statistic = –2·703 with 114 degrees of freedom and the critical value of t = 1·684; therefore H_o cannot be rejected and differences in erosion rates between Type

Table V. Summary erosion data from the Kaikoura Peninsula

Platform type	Profile	Equivalent mean annual erosion rate (mm a^{-1})
Type B	KM1	0·614
Type A	KM2	1·740
Type B	KM3	0·747
Type A	KM4	0·910
Type B	KM5	0·839
Type A	KM6	2·226
Type A	KM7	0·839
All profiles grand mean		1·130
All mudstone profiles		1·233
All limestone profiles		0·875
Mudstone Type A	KM2, KM3	1·983
Limestone Type A	KM4, KM7	1·428
Mudstone Type B	KM1, KM3, KM5	0·733

A and Type B platforms are not statistically significant. Kirk's (1977) results showed that mudstone platform erosion rates were higher (1·21 mm a^{-1}) than limestone platforms (0·69 mm a^{-1}) based on mean erosion rates, but a Mann–Whitney U-test showed no significant difference.

Despite absolute differences in erosion rates, all results are within the same order of magnitude as those reported by Kirk (1977) and Stephenson and Kirk (1996) for the Kaikoura Peninsula, and in other studies from around the world. The statistically similar erosion rates between Type A and Type B platforms has an important implication for Tsujimoto's (1987) demarcation of Type A and Type B shore platforms. He assumed that on Type B platforms there was no surface lowering caused by wave erosion. Clearly from the above results there is lowering and at about the same rate as that measured for Type A platforms. Evidence also suggests that this lowering results from subaerial processes rather than marine processes as proposed by Tsujimoto (1987).

The results presented here provide evidence that subaerial weathering is the process group causing the development of shore platforms at Kaikoura rather than marine processes. Higher erosion rates during summer imply that wetting and drying and salt weathering are operating. Environmental conditions needed to cause these processes are at their most effective during summer, when higher temperatures aid drying. Wetting is achieved through tidal submergence or rainfall. One other factor influences erosion rates. Growth of algae during winter months slows erosion significantly. Cross-shore patterns of erosion showed higher rates on the inner margins of platforms. This evidence, and tidal data from Kirk (1977) which showed that the inner parts of platforms are submerged less often (only 21 per cent of the year), indicates that weathering is more effective there than on the more seaward parts of platforms. There is seasonality in surface lowering rates on the seaward margins of platforms which indicates that subaerial weathering is also important here, but given that these parts of platforms are submerged for up to 88 per cent of the year (Kirk, 1977) then it is not surprising to find lower erosion rates, because submergence prevents drying. Subaerial weathering is most effective on the inner margins of platforms, where erosion rates are highest. From the analysis presented, it is argued that shore platform development at Kaikoura results from subaerial weathering rather than the wave erosive forces. However, the removal of weathered material can only be achieved through marine processes, probably wave- and tide-generated currents, but the development of platforms cannot proceed without subaerial weathering occurring first. This view that weathering is a primary factor is contrary to recent views of shore platform development contained in the literature.

CONCLUSIONS

This paper has presented measured rates and patterns of erosion on shore platforms on the Kaikoura Peninsula. The mean lowering rate for shore platforms at Kaikoura was 1·130 mm a^{-1}. A number of findings have been made with regard to erosion on shore platforms. Surface lowering appeared to be different by an order of magnitude on mudstone Type A (1·983 mm a^{-1}) and Type B platforms (0·733 mm a^{-1}). It was higher on mudstone (1·233 mm a^{-1}) compared with limestone platforms (0·875 mm a^{-1}). Statistically these were not

significantly different and lithology is not a control of mean erosion rates. Erosion rates did not display the same cross-shore pattern as found by Kirk (1977). Generally, rates were higher on the inner landward margin of platforms and decreased seaward. This pattern was not found on all study sites; at one site the pattern occurred in the opposite direction. Higher erosion rates on the landward margins of platforms indicate that extension of the platforms is continuing.

The analysis of erosion patterns led to the proposal that erosion was linked to season. Rates of erosion were higher during the summer compared with the winter. Chi-square tests showed an association between season and erosion. A seasonal control indicates that subaerial weathering is the process causing the development of shore platforms at Kaikoura. It has been argued that platforms at Kaikoura are weathered features rather than wave-cut landforms. There is a clear need for further investigation of processes operating on shore platforms to reassess the view that marine processes cause shore platform development.

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